

11.5 Site Suitability

Consider the following site characteristics:

- Sufficient land area
- Adequate TSS control or pretreatment capability
- Compliance with environmental objectives
- Adequate influent flow attenuation and/or bypass capability
- Sufficient access for operation and maintenance (O & M)

11.6 Design Criteria-General Considerations

There is concern that oil/water separators used for stormwater treatment have not performed to expectations. (Watershed Protection Techniques, 1994; Schueler, Thomas R., 1990) Therefore, emphasis should be given to proper application (see Section 11.4), design, O & M, (particularly sludge and oil removal) and prevention of CP fouling and plugging. (US Army of Engineers, 1994) Other treatment systems, such as sand filters and emerging technologies, should be considered for the removal of insoluble oil and TPH.

The following are design criteria applicable to API and CP oil/water separators:

- If practicable, determine oil/grease (or TPH) and TSS concentrations, lowest temperature, pH; and empirical oil rise rates in the runoff, and the viscosity, and specific gravity of the oil. Also determine whether the oil is emulsified or dissolved. (Washington State Department of Ecology, 1995) Do not use oil/water separators for the removal of dissolved or emulsified oils such as coolants, soluble lubricants, glycols, and alcohols.
- Locate the separator off-line and bypass the incremental portion of flows that exceed the off-line in excess of 2.15 times the 15-minute, Water Quality design flow rate multiplied by the ratio indicated in Figure 9.5b of this Volume. If it is necessary to locate the separator on-line, try to minimize the size of the area needing oil control, and use the on-line water quality design flow rate multiplied by the ratio indicated in Figure 9.5a.
- Use only impervious conveyances for oil contaminated stormwater.
- Specify appropriate performance tests after installation and shakedown, and/or certification by a professional engineer that the separator is functioning in accordance with design objectives. Expedient corrective actions must be taken if it is determined the separator is not achieving acceptable performance levels.

- Add pretreatment for TSS that could cause clogging of the CP separator, or otherwise impair the long-term effectiveness of the separator.

Criteria for Separator Bays:

- Size the separator bay for the Water Quality design flow rate (15 minute time step) x a correction factor ratio indicated in Figure 9.5b of this Volume (assuming an off-line facility) of 2.15. (See Chapter 4 of this Volume for a definition of the Water Quality Design Flow Rate.)
- To collect floatables and settleable solids, design the surface area of the forebay at $\geq 20 \text{ ft}^2$ per 10,000 ft^2 of area draining to the separator⁽⁶⁾. The length of the forebay should be 1/3-1/2 of the length of the entire separator. Include roughing screens for the forebay or upstream of the separator to remove debris, if needed. Screen openings should be about 3/4 inch.
- Include a submerged inlet pipe with a turn-down elbow in the first bay at least two feet from the bottom. The outlet pipe should be a Tee, sized to pass the design peak flow and placed at least 12 inches below the water surface.
- Include a shutoff mechanism at the separator outlet pipe. (King County Surface Water Management, 1998)
- Use absorbents and/or skimmers in the afterbay as needed.

Criteria for Baffles:

- Oil retaining baffles (top baffles) should be located at least at 1/4 of the total separator length from the outlet and should extend down at least 50% of the water depth and at least 1 ft. from the separator bottom.
- Baffle height to water depth ratios should be 0.85 for top baffles and 0.15 for bottom baffles.

11.7 Oil and Water Separator BMPs

Two BMPs are described in this section. BMP T11.10 for baffle type separators, and BMP T11.11 for coalescing plate separators.

BMP T11.10 -API (Baffle type) Separator Bay

Design Criteria

The criteria for small drainages is based on V_h , V_t , residence time, width, depth, and length considerations. As a correction factor API's turbulence criteria is applied to increase the length.

Ecology is modifying the API criteria for treating stormwater runoff from small drainage area (fueling stations, commercial parking lots, etc.) by using the design hydraulic horizontal velocity, V_h , for the design V_h/V_t ratio rather than the API minimum of $V_h/V_t = 15$. The API criteria appear applicable for greater than two acres of impervious drainage area. Performance verification of this design basis must be obtained during at least one wet season using the test protocol referenced in Chapter 12 for new technologies.

The following is the sizing procedure using modified API criteria:

- Determine the oil rise rate, V_t , in cm/sec, using Stokes Law (Water Pollution Control Federation, 1985), or empirical determination, or 0.033 ft./min for 60 μ oil. The application of Stokes' Law to site-based oil droplet sizes and densities, or empirical rise rate determinations recognizes the need to consider actual site conditions. In those cases the design basis would not be the 60 micron droplet size and the 0.033 ft/min. rise rate.
- Stokes Law equation for rise rate, V_t (cm/sec):

$$V_t = g(\sigma_w - \sigma_o)D^2 / 18\eta_w$$

Where:

g = gravitational constant (981 cm/sec²)

D = diameter of the oil particle in cm.

Use

oil particle size diameter, $D=60$ microns (0.006 cm)

$\sigma_w = 0.999$ gm/cc. at 32° F

σ_o : Select conservatively high oil density,

For example, if diesel oil @ $\sigma_o = 0.85$ gm/cc and motor oil @ $\sigma_o = 0.90$ can be present then use $\sigma_o = 0.90$ gm/cc

$\eta_w = 0.017921$ poise, gm/cm-sec. at $T_w = 32$ °F, (See API Publication 421, February , 1990)

Use the following separator dimension criteria:

Separator water depth, $d \geq 3 \leq 8$ feet (to minimize turbulence)
(American Petroleum Institute, 1990; US Army Corps of Engineers, 1994).

Separator width, 6-20 feet (WEF & ASCE, 1998; King County Surface Water Management, 1998)

Depth/width (d/w) of 0.3-0.5 (American Petroleum Institute, 1990)

For Stormwater Inflow from Drainages under 2 Acres:

1. Determine V_t and select depth and width of the separator section based on above criteria.
2. Calculate the minimum residence time (t_m) of the separator at depth d:

$$t_m = d/V_t$$

3. Calculate the horizontal velocity of the bulk fluid, V_h , vertical cross-sectional area, A_v , and actual design V_h/V_t (American Petroleum Institute, 1990; US Army Corps of Engineers, 1994).

$V_h = Q/dw = Q/A_v$ (V_h maximum at < 2.0 ft/min.)(American Petroleum Institute, 1990)

$Q = 2.15 \times (k)$ the ratio indicated in Figure 9.5b for the site location multiplied by the 15-minute Water Quality design flow rate in ft³/min, at minimum residence time, t_m

At V_h/V_t determine F, turbulence and short-circuiting factor (Appendix V-D) API F factors range from 1.28-1.74. (American Petroleum Institute, 1990)

4. Calculate the minimum length of the separator section, $l(s)$, using:

$$\begin{aligned}l(s) &= FQt_m/dw = F(V_h/V_t)d \\l(t) &= l(f) + l(s) + l(a) \\l(t) &= l(t)/3 + l(s) + l(t)/4\end{aligned}$$

Where:

$l(t)$ = total length of 3 bays = “L” in Figure 11.1
 $l(f)$ = length of forebay
 $l(a)$ = length of afterbay

5. Calculate $V = l(s)wd = FQt_m$, and $A_h = wl(s)$

V = minimum hydraulic design volume
 A_h = minimum horizontal area of the separator

For Stormwater Inflow from Drainages > 2 Acres:

Use $V_h = 15 V_t$ and $d = (Q/2V_h)^{1/2}$ (with $d/w = 0.5$) and repeat above calculations 3- 5.

BMP T11.11 - Coalescing Plate (CP) Separator Bay

Design Criteria

Calculate the projected (horizontal) surface area of plates needed using the following equation:

$$A_p = Q/V_t = Q/0.00386(\sigma_w - \sigma_o/\eta_w)$$

$$A_p = A_a(\cosine b)$$

Where:

$Q = k$ (the ratio appropriate for the project location) indicated by Figure 9.5b2.15 x the 15-minute water quality design flow rate, ft³/min

V_t = Rise rate of 0.033 ft/min, or empirical determination, or Stokes Law based

A_p = projected surface area of the plate in ft²; .00386 is unit conversion constant

σ_w = density of water at 32° F

σ_o = density of oil at 32° F

A_a = actual plate area in ft² (one side only)

b = angle of the plates with the horizontal in degrees (usually varies from 45-60 degrees).

η_w = viscosity of water at 32° F

- Plate spacing should be a minimum of 3/4 in (perpendicular distance between plates). (WEF & ASCE, 1998; US Army Corps of Engineers, 1994; US Air Force, 1991; Jaisinghani, R., 1979)
- Select a plate angle between 45° to 60° from the horizontal.
- Locate plate pack at least 6 inches from the bottom of the separator for sediment storage
- Add 12 inches minimum head space from the top of the plate pack and the bottom of the vault cover.
- Design inlet flow distribution and baffles in the separator bay to minimize turbulence, short-circuiting, and channeling of the inflow especially through and around the plate packs of the CP separator. The Reynolds Number through the separator bay should be <500 (laminar flow).